

Residential Roof Construction and Assemblies

presented by: russell thornburg

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Building Contractor - 1984 to present
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Reference and Resources Material

- ▶ 2012 *International Residential Code*® (IRC ®)
- ▶ Significant Changes to the IRC 2012 Edition



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IRC - Preface

Introduction

- ▶ This comprehensive, **stand-alone** residential code establishes minimum regulations for one - and two -family dwellings and townhouses using prescriptive provisions.

Development

- ▶ This code is founded on principles **intended to establish** provisions consistent with the scope of a residential code **that adequately protects public health, safety and welfare; ...**

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Seminar Materials



Roof-Ceiling Construction

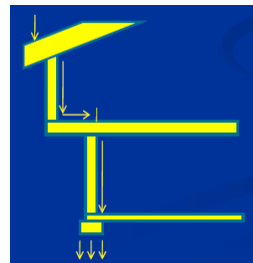
Chapter 8



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Roof-Ceiling Construction

- Roof and ceiling construction shall be capable of accommodating all loads imposed according to Section R301 and of transmitting the resulting loads to the supporting structural elements.

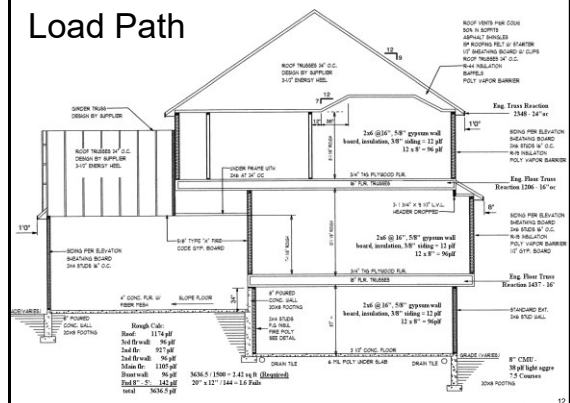


R801.2 Requirements

Load Path



Load Path



Roof-Ceiling Construction

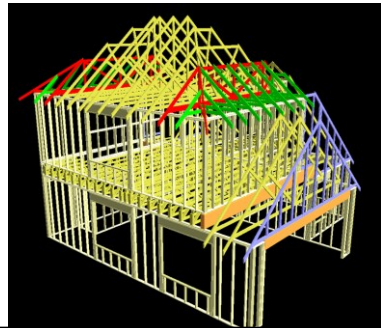
The purpose of roof framing is to transmit the roof loads to the supporting structure below.

- Rafters
- Trusses
- Hips and valleys
- Ridge boards, beams



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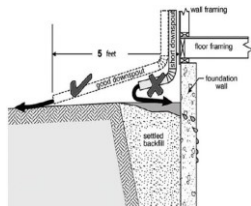
- Think top-down
KEY CONCEPT Load Path



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Roof-Ceiling Construction

- Where expansive or collapsible soils are known to exist,
- All dwellings shall have a controlled method of water disposal from roofs
- That will collect and discharge roof drainage to the ground surface at least 5' from foundation walls **or**
- to an approved drainage system.



R801.3 Roof drainage

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Roof-Ceiling Construction

- Load-bearing dimension lumber for rafters, trusses and ceiling joists shall be identified by a grade mark



R802.1 Identification

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Roof-Ceiling Construction

- Approved end-jointed lumber identified by a grade mark conforming to Section R802.1.1 may be used interchangeably with solid-sawn members of the same species and grade.
- End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation "Heat-Resistant Adhesive" or "HRA" included in its grade mark.



R802.1.1.1 End-jointed lumber

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Roof-Ceiling Construction

- Fire-retardant-treated wood (FRTW)
- Shall have been tested in accordance with ASTM E 84 **or** UL 723,
- Listed flame spread index of 25 **or less and**
- Shows no evidence of significant progressive combustion when the test is continued for an additional 20-minute period...



R802.1.5 Fire-retardant-treated wood.

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Roof-Ceiling Construction

Fire-retardant-treated lumber and wood structural panels shall be labeled. The label shall contain:

1. The identification mark of an approved agency in accordance with Section 1703.5 of the International Building Code.
2. Identification of the treating manufacturer.
3. The name of the fire-retardant treatment.
4. The species of wood treated.
5. Flame spread index and smoke-developed index.
6. Method of drying after treatment.
7. Conformance to applicable standards in accordance with Sections R802.1.5.5 through R802.1.5.8.
8. For FRTW exposed to weather, or a damp or wet location, the words "No increase in the listed classification when subjected to the Standard Rain Test" (ASTM D 2898).



R802.1.5.4 Labeling

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Roof-Ceiling Construction

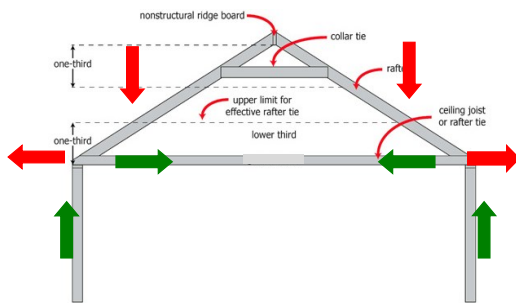
- The framing details apply to roofs with a pitch of 3:12 or greater
- Where the roof pitch is less than 3:12 (25%), structural members that support rafters, such as ridges, hips & valleys, shall be designed as beams, & bearing shall be provided for rafters in accordance with [Section R802.6](#).



R802.4.4 Rafter support

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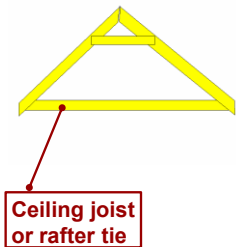
Rafter/Ceiling Joist System



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Rafter/Ceiling Joist System

- Clarifies that it was never the intent to permit rafter ties to resist thrust when installed above 1/3 the distance from the top plate to the roof ridge board.



Tables R802.5.1 (1) through R802.5.1 (2)

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Framing Details

Ridge Board:

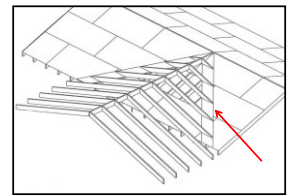
- Compression member
- Minimum nominal thickness of 1"
- Depth equal to or greater than rafter cut



R802.3

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Ceiling Joist and Rafter Framing



At all valleys and hips there shall be a valley or hip rafter not less than 2-inch nominal thickness and not less in depth than the cut end of the rafter.

R802.4.3 Hips and Valleys

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Roofs – Structural Member Sizing

- > 12:12 pitch roof



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Ceiling Joist Design

- Spans for ceiling joists shall be in accordance with Tables R802.4(1) and R802.4(2). For other grades and species and for other loading conditions, refer to the AF&PA Span Tables for Joists and Rafters.



http://www.afpa.org/pdf/STJR_2005.pdf

R802.4 Allowable ceiling joist spans

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Ceiling Joist Design Check

- Table R802.4(1) for no storage.
- Table R802.4(2) for limited storage.
- Known values:
 - Ceiling joist size and spacing.
 - Lumber species and grade.
 - Attic dead load.
 - Deflection limit.

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Ceiling Joist Design Check

TABLE R802.5.1(6)
RAFTER SPANS FOR COMMON LUMBER SPECIES
(Ground snow load=50 psf, ceiling attached to rafters, L/A = 240)

RAFTER SPACING (inches)	SPECIES AND GRADE	DEAD LOAD = 10 psf				DEAD LOAD = 20 psf			
		2 x 4	2 x 6	2 x 8	2 x 10	2 x 4	2 x 6	2 x 8	2 x 10
		(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)
24	Douglas fir-larch SS	6-1	9-7	12-7	15-10	18-4	6-1	9-6	12-0
	Douglas fir-larch #1	5-10	8-6	10-9	13-2	15-3	5-5	7-10	10-0
	Douglas fir-larch #2	5-5	7-11	10-1	12-4	14-3	5-0	7-4	9-4
	Douglas fir-larch #3	4-1	6-0	7-7	9-4	10-9	3-10	5-7	7-1
	Hem-fir SS	5-9	9-1	11-11	14-2	16-0	5-9	9-1	11-9
	Hem-fir #1	5-8	8-3	10-6	12-10	14-10	5-3	7-8	9-9
	Hem-fir #2	5-4	7-10	9-11	12-1	14-1	4-11	7-3	9-2
	Hem-fir #3	4-1	6-0	7-7	9-4	10-9	3-10	5-7	7-1
	Southern pine SS	6-0	9-5	12-5	15-10	19-3	6-0	9-5	12-5
	Southern pine #1	5-10	9-3	12-0	14-4	17-1	5-10	8-10	11-2
	Southern pine #2	5-9	8-4	10-9	12-10	15-1	5-5	7-8	10-0
	Southern pine #3	4-4	6-5	8-3	9-8	11-7	4-1	6-0	7-7
	Spruce-pine-fir SS	5-8	8-10	11-8	14-9	17-1	5-8	8-10	11-2
	Spruce-pine-fir #1	5-5	7-11	10-1	12-4	14-3	5-0	7-4	9-4
	Spruce-pine-fir #2	5-0	7-11	9-8	12-4	14-3	5-0	7-4	9-4
	Spruce-pine-fir #3	4-1	6-0	7-7	9-4	10-9	3-10	5-7	7-1

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Ceiling Joist Design Check

Table R802.5.1(1) – continued
CEILING JOIST SPANS FOR COMMON LUMBER SPECIES
(Uninhabitable attics without storage, live load = 10 psf, L/A = 240)

CEILING JOIST SPACING (inches)	SPECIES AND GRADE	2 x 4	2 x 6	2 x 8	2 x 10
		(feet-inches)	(feet-inches)	(feet-inches)	(feet-inches)
		Maximum ceiling joist spans			
24	Douglas fir-larch SS	10-5	16-4	21-7	Note a
	Douglas fir-larch #1	10-0	15-9	20-1	24-6
	Douglas fir-larch #2	9-10	14-10	18-9	22-11
	Douglas fir-larch #3	7-8	11-2	14-2	17-4
	Hem-fir SS	9-10	15-6	20-5	Note a
	Hem-fir #1	9-8	15-2	19-7	23-11
	Hem-fir #2	9-2	14-5	18-6	22-7
	Hem-fir #3	7-8	11-2	14-2	17-4
	Southern pine SS	10-3	16-1	21-2	Note a
	Southern pine #1	10-0	15-9	20-10	Note a
	Southern pine #2	9-10	15-6	19-1	23-11
	Southern pine #3	8-2	12-0	15-4	18-1
	Spruce-pine-fir SS	9-8	15-2	19-11	25-5
	Spruce-pine-fir #1	9-5	14-9	18-9	22-11
	Spruce-pine-fir #2	9-5	14-8	18-8	22-11
	Spruce-pine-fir #3	7-8	11-2	14-2	17-4

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Rafter Design Check

- Table R802.4(1) – (8) for various live load or ground snow load.
- Known values:
 - Ground snow load (20, 30, 50 & 70 PSF).
 - Dead load.
 - Rafter size and spacing.
 - Lumber species and grade.
 - Span length.
 - Finish material on rafters (deflection).

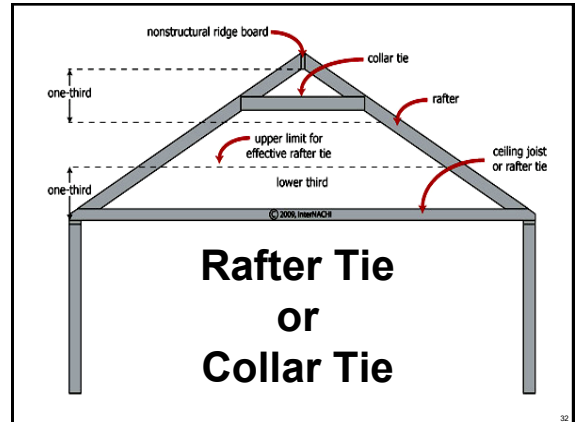
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Rafter Span Adjustment

- Raise ceiling joist/rafter tie.
- Maximum 1/3 height of rafter.
- H_C = height of rafter tie above bearing point.
- H_R = height of rafter above bearing.
- Use table to determine adjustment.
- Multiply tabular span length with adjustment.

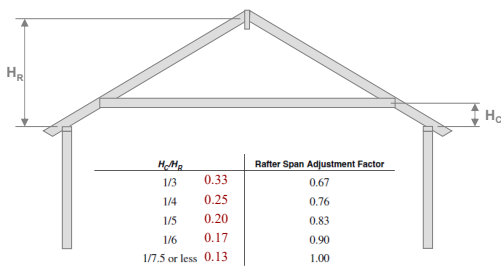
Figure 802.4.5 Braced Rafter Construction

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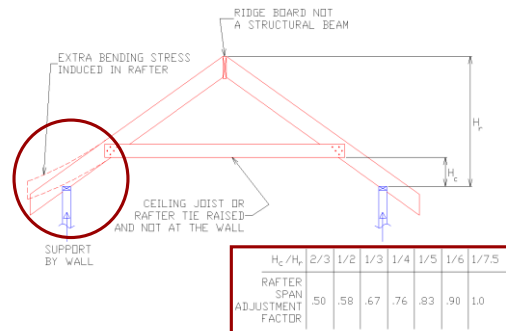
32

Rafter Span Adjustment



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Roofs – Structural Member Sizing



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Rafter Opposing



R802.4.2 Framing details

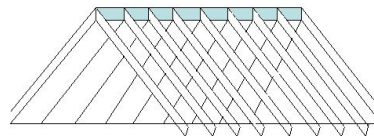
35

- Does the IRC require rafters to be directly opposing one another when framed to the ridge board?
- **A:** Yes or No. Section R802.4.2 requires the rafters to be framed to each other (directly opposing) with a gusset plate or framed to a ridge board.

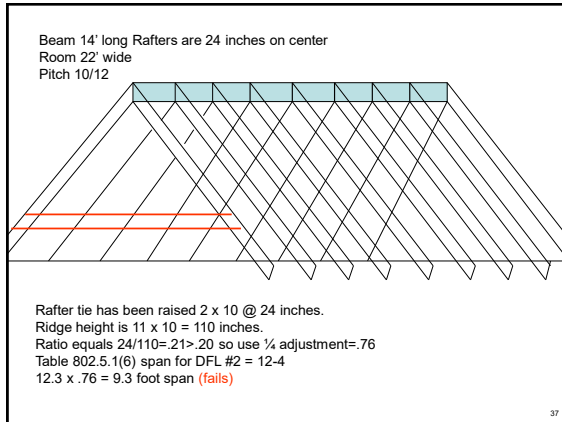
Ridge must be designed as a beam: R802.3.1:
 Given: 14 foot ridge for a roof that is 22 feet wide:
 $Plf = (35 \times 10) \times 11 = 495$ Use LP-LVL at 2,400 fb
 $[495 \times 14 \times 14 \times 12] \div [8 \times 2,400] = 6S^3$
 Snow load reduction .85 $\times 279 = 60.6S^3$ required

Assume 2 – 11.25 x 1.75
 $[11.25 \times 11.25 \times 1.75 \times 2] \div 6 = 73.8S^3$ provided

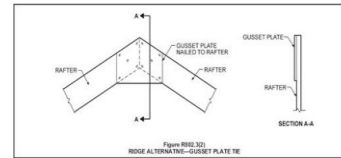
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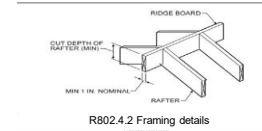
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Ridge Layout



Figures R802.4(2) and R802.4(1)



When using a ridge board if the rafters are not directly opposite each other it is no longer a ridge beam. A ridge beam requires a design in accordance with Section R301.1.3.

Framing Details

- Minimum nominal thickness of 2"
- Minimum depth equal to rafter cut
- Must be designed as beams for < 3:12 slope.



R802.4.3

Collar Ties vs. Rafter Ties

- Collar ties are in the upper third of the attic
 - Collar ties shall be a minimum of a 1 X 4 and spaced not more than 4 feet apart
 - Ridge straps shall be not less than $1\frac{1}{4}$ " x 20 gage & shall be nailed to the top edge of each rafter with no fewer than three 10d common ($3" \times 0.148"$) nails with the closest nail not closer than $2\frac{3}{8}"$ from the end of the rafter

R802.4.6 Collar ties

Collar Ties vs. Rafter Ties

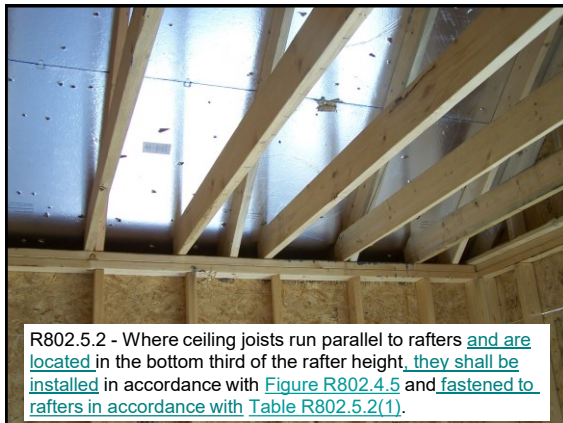
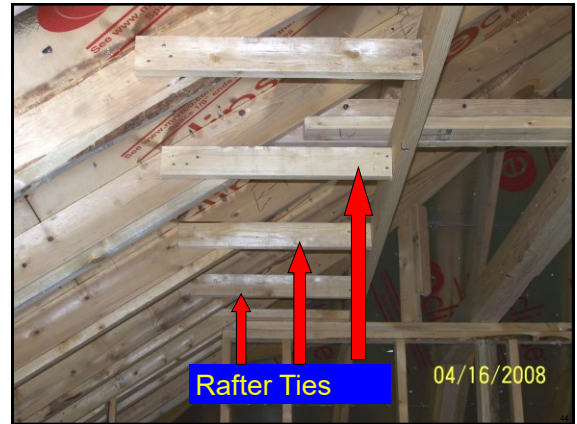
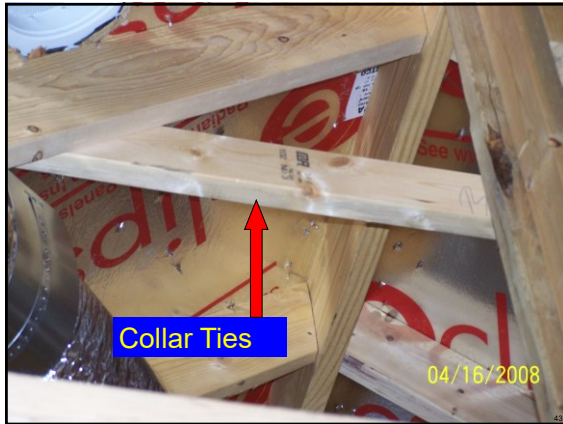
- Ceiling Joist / Rafter ties **and are located from the upper third and down** installed in accordance with Figure R802.4.5 and fastened to rafters in accordance with Table R802.5.2(1)
- Rafter ties shall be a minimum of a 2 X 4 installed in accordance with Table R802.5.2(1) at a max. 24" o.c. Other approved rafter tie methods shall be permitted.
- Ceiling joists/rafter tie that are above the bottom $\frac{1}{3}$ of the rafter height, the ridge shall be designed as a beam in accordance with Section R802.3.

Table R802.4.1(1) - (8) ft. a & Figure 802.4.5

Ceiling Joists / Rafter Tie

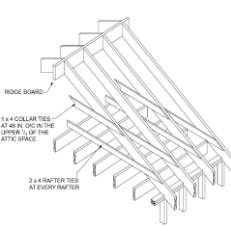
Where ceiling joists do not run parallel to rafters, rafters shall be tied across the structure with a rafter tie in accordance with Section R802.5.2.2, or the ridge shall be designed as a beam in accordance with Section R802.3.

R802.5.2 Ceiling joist and rafter connections



Framing Details

- If a rafter tie is not located at the rafter support wall, an increase in the connection for the rafter tie must be calculated following Note f of [Table R802.5.2\(1\)](#).
- Rafter ties located at the lower third point of the rafter span must have a 50-percent increase in the number of nails creating the connection of the rafter tie to the rafter.



NOTE: LOCATE RAFTER TIE AS NEAR AS POSSIBLE TO THE TOP OF CEILING JOIST

Commentary Figure R802.5.2 ROOF FRAMING WITH CEILING JOISTS NOT PARALLEL TO RAFTERS

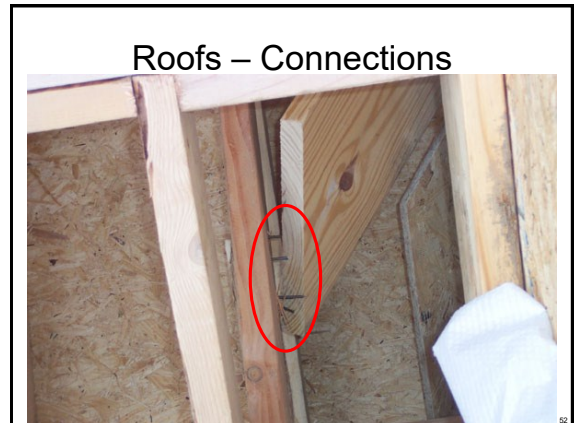
R802.5.2.2 Rafter Ties ICC Commentary

Ceiling Joists Lapped

- Ends of ceiling joists shall be lapped a minimum of 3 inches
- Or butted over bearing partitions or beams and toe-nailed to the bearing member

R802.5.2.1 Ceiling joists lapped





Roofs - Connections

- Fastener schedules

Nail Sizes in the IRC

Penny Weight	Length x Dia.
16d	3½" × 0.135"
10d common	3" × 0.148"
10d	3" × 0.128"
8d common	2½" × 0.131"
8d	2½" × 0.113"
6d common	2" × 0.113"

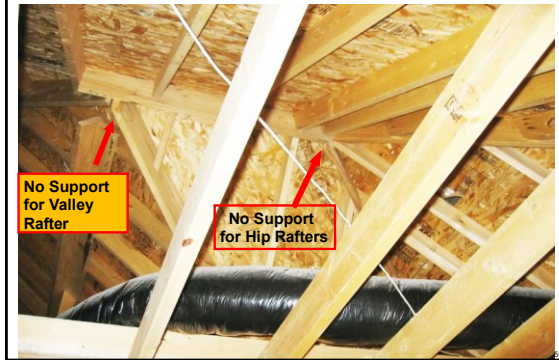


Hips and Valley Rafters

- Hip and valley rafters shall be not less than 2" nominal in thickness . .
- . . and not less in depth than the cut end of the rafter.
- Hip and valley rafters shall be supported at the ridge by a brace to a bearing partition...
- . . .or be designed to carry and distribute the specific load at that point.

R802.4.3 Hips and valleys.

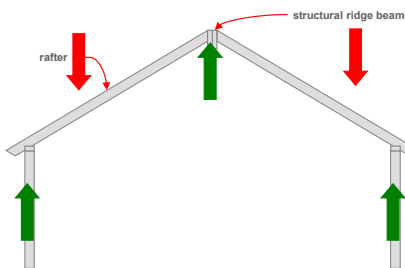
Roofs – Load Path



Roofs – Support

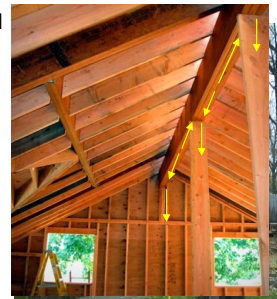


Rafter/Ridge Beam System



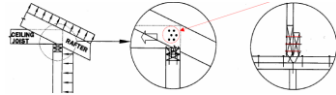
Ridge Beam Load Path

- Follow ridge beam load path.
- Ensure columns, multiply studs support beam.
- Materials:
 - Large dimensioned lumber.
 - LVL, microlam.
 - Steel.
 - Flitch beam.



Ceiling Joist and Rafter Connections

- [Table R602.3\(1\)](#) provides general nailing schedule for roof connections
- [Table R802.5.2\(1\)](#) regulates rafter/ceiling joist connection based on ground snow load
- Ceiling joists to be continuous or securely nailed where meeting over interior partitions
 - Where parallel to rafters, also nailed to adjacent rafters to provide a continuous tie



R802.3.1

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Fastening Schedule

2006 IRC

TABLE R602.3(1)
FASTENER SCHEDULE FOR STRUCTURAL MEMBERS

DESCRIPTION OF BUILDING ELEMENTS	NUMBER AND TYPE OF FASTENER-A ^a	SPACING OF FASTENERS
Joist to sill or gable end wall	3-6d (2 1/2" x 0.113")	---
1" x 6" subfloor or less to each post, face nail	2-8d (2 1/2" x 0.113")	---
2" subfloor to joist or gable, blind and face nail	2-16d (3 1/2" x 0.135")	---
Sole plate to joist or gable, blind and face nail	16d (3 1/2" x 0.135")	16" o.c.
Top or sole plate to stud, end nail	2-16d (3 1/2" x 0.135")	---
Stud to sole plate, toe nail	3-8d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135")	---
Double studs, face nail	10d (3" x 0.120")	24" o.c.
Double top plates, face nail	10d (3" x 0.120")	24" o.c.

2021 IRC

Table R602.3(1) Fastening Schedule

DESCRIPTION OF BUILDING ELEMENTS	NUMBER AND TYPE OF FASTENER-A ^a	SPACING OF FASTENERS
1. Absorbing fasteners (including plates, rafters or trusses) to top plates or rafter framing members	3-6d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	Top rafter
2. Absorbing fasteners (including plates, rafters or trusses) to top plates or rafter framing members	3-6d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	Blacks and top rafter
3. First absorbing joist to rafter about every 16d	16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	16" o.c. Rafter rafter
4. Ceiling joist to top plate	3-6d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	First joist, top rafter
5. Ceiling joist to rafter about every 16d	3-6d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	First joist
6. Ceiling joist to rafter about every 16d	3-6d (2 1/2" x 0.113") or 2-16d (3 1/2" x 0.135") or 2-10d (3" x 0.120")	First joist

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Table R802.5.2(1) - Rafter/Ceiling Joist Heel Joints Connections *

		GIRDLING SNOW LOAD (psf)															
		20"				30"				50"				70"			
RAFTER SLOPE	RAFTER SPACING (inches)	Roof span (feet)															
		12	24	36	48	12	24	36	48	12	24	36	48	12	24	36	48
		Required number of full cross-section nails per joint point subject to $\phi_t \times V$															
3:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	7	10	14	8	12	16	20	12	17	21	28	15	22	27	36
	19.2	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
4:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
5:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
6:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
7:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
8:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
9:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14
10:12	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	18	4	8	12	16	10	14	7	10	14	7	10	14	7	10	14	21
	19.2	3	6	9	12	5	7	4	7	10	14	7	10	14	7	10	14

a. 10d common (3" x 0.148") nails shall be permitted to be substituted for 16d common (3 1/2" x 0.135") nails where the required number of nails is less than 1.2 times the required number of 16d common nails, rounded up to the next full nail.

- Heel joint connections are not required where the ridge is supported by a load-bearing wall, header or ridge beam.
- Where intermediate support of the rafter is provided by vertical studs or parties to a load-bearing wall, the tabulated heel joint connection requirements shall be permitted to be reduced proportionally to the reduction in span.
- Equivalent nailing patterns are required for ceiling joist to ceiling joist top rafters.
- Applies to roof live load of 20 psf or less.
- Tabulated heel joint connection requirements assume that ceiling joists or rafter ties are located at the bottom of the attic space. Where ceiling joists or rafter ties are located higher in the attic, heel joint connection requirements shall be increased by the adjustment factors in Table R802.5.2(2).
- Tabulated requirements are based on 10 psf roof dead load in combination with the specified roof snow load and roof live load.

63

Ceiling joist and rafter connections

- Note d. Where ceiling joists or rafter ties are located above the top plate, the joint connection should have the nail adjustment factor applied from [Table R802.5.2\(2\)](#) to adjust the number of fasteners from [Table R802.5.2\(1\)](#).

TABLE R802.5.2(2) HEEL JOINT CONNECTION ADJUSTMENT FACTORS

H _c /H _r ^{a, b}	HEEL JOINT CONNECTION ADJUSTMENT FACTOR
1/3	1.5
1/4	1.33
1/5	1.25
1/6	1.2
1/10 or less	1.11

a. H_c = Height of ceiling joists or rafter ties measured vertically from the top of the rafter support walls to the bottom of the ceiling joists or rafter ties; H_r = Height of roof ridge measured vertically from the top of the rafter support walls to the bottom of the roof ridge.
b. Where H_c/H_r exceeds 1/3, connections shall be designed in accordance with accepted engineering practice.

R802.5.2 Ceiling joist and rafter connections.

64

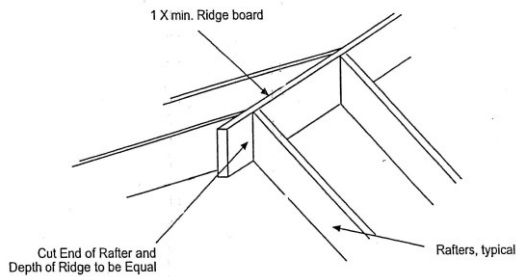


65



66

R802.6 Bearing
Minimum 1 1/2" on wood & 3" on concrete or masonry...
don't forget about load path.

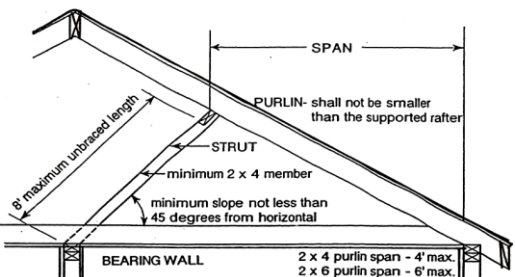
R802.3 Framed rafter/ridge detail

67



68

Strut
Size of purlin
Angle of strut, size of strut
Purlin span
Length of strut

R802.5.1 Purlins

69

Cutting and Notching

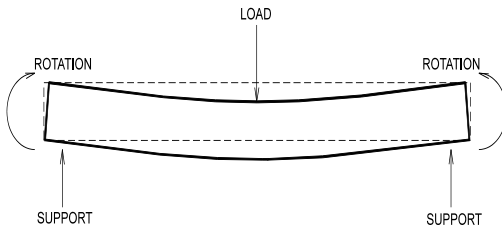
Section R802.7

- Notches regulated in solid lumber joists, rafters and beams
 - Depth of notch limited to 1/6 of member depth
 - Depth limit of 1/4 of member depth where notch at end of member
 - Length of notch limited to 1/3 the depth of the member
 - Notches not to be located in middle 1/3 of member span
 - Members 4 inches or more in thickness may be notched on tension side only at ends
- Notches permitted on cantilevered portion of rafters, provided:
 - Rafter maintains minimum 4-inch nominal dimension, and
 - Cantilever length does not exceed 24 inches

70

Cutting, Notching & Bored Holes

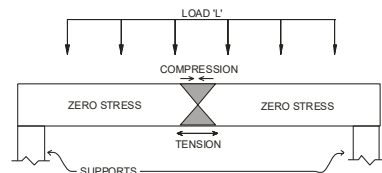
- Simple Span



71

Cutting, Notching & Bored Holes

- Tension vs. Compression



72



Cutting and Notching

Section R802.7

- Bored holes regulated in solid lumber joists, rafters and beams
 - Diameter of bored holes limited to $1/3$ of member depth
 - Bored holes to be located at least 2 inches from top or bottom of member
- Bored hole to be separated at least 2 inches from adjacent notch
- In engineered wood products such as laminated veneer lumber, glue-laminated members or I-joists, notches and bored holes prohibited unless specifically considered in design of member

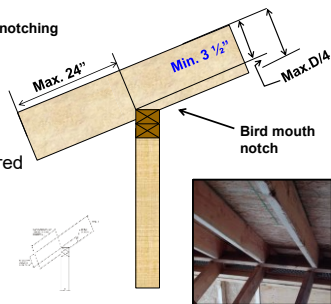
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76

Cantilevered portions of rafters

R802.7 Cutting, drilling and notching



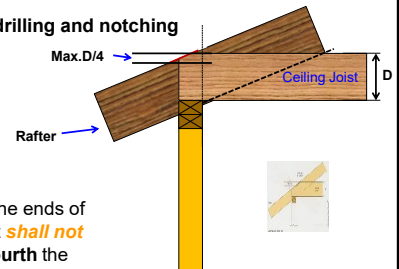
- Notches on cantilevered rafters are permitted
- Rafter is $< 3 \frac{1}{2}$ " and the length of the cantilever does not exceed 24" in Figure R802.7.1.1.

R802.7.1.1

77

Ceiling joist taper cut

R802.7 Cutting, drilling and notching



- Taper cuts at the ends of the ceiling joist **shall not** exceed **one-fourth** the depth of the member in accordance with Figure R802.7.1.2.

78

Framing of Openings

Section R802.9

- Openings in roof and ceiling framing to be framed with header and trimmer joists
- Where header span limited to 4 feet, single header joist permitted
 - Single trimmer joists permitted for single header joist where within 3 feet of trimmer joist bearing
- Where header span exceeds 4 feet, header joists and trimmer joists to be doubled

79



Uplift Resistance



R802.11 Roof tie uplift resistance.

Roof assemblies shall have uplift resistance in accordance with Sections R802.11.1 and R802.11.2.

Exceptions: Rafters or trusses shall be permitted to be attached to their supporting wall assemblies in accordance with Table R802.3(1) where either of the following occur:

- Where the uplift force per rafter or truss does not exceed 200 lbs. as determined by Table R802.11.
- Where the basic wind speed does not exceed 115 miles per hour the wind exposure category is B, the roof pitch is 5 units vertical in 12 units horizontal (or greater, the roof span is 32' or less, and rafters and trusses are spaced not more than 24" o.c.

R802.11.1

81

Uplift Resistance

R802.11.1.2 Truss uplift resistance.

Trusses shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as specified on the truss design drawings. Uplift forces shall be permitted to be determined as specified by Table R802.11, *if applicable*, or as determined by accepted engineering practice.

R802.11.1.3 Rafter uplift resistance.

Individual rafters shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as determined by Table R802.11 or as determined by accepted engineering practice. Connections for beams used in a roof system shall be designed in accordance with accepted engineering practice.

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Ceiling Construction

Table R802.11. Rafter or Truss Uplift Connection
Forces from Wind (ASD) (POUNDS PER CONNECTION) EXPOSURE B

RAFTER OR TRUSS SPACING	RAFTER OR TRUSS SPACING	Minimum Design Wind Speed, V _W , (mph)									
		110		115		120		125		130	
		R	R	R	R	R	R	R	R	R	R
12" o.c.	12"	48	43	39	35	70	64	57	50	122	113
	16"	59	52	47	42	86	78	69	60	152	140
	20"	71	63	57	51	104	94	83	72	182	168
	24"	84	75	68	61	121	110	97	85	210	195
	32"	98	88	80	72	142	129	114	100	248	229
	40"	115	102	93	84	166	151	134	118	290	268
	48"	135	120	110	99	195	178	157	139	342	315
	56"	158	141	130	118	228	208	184	163	398	366
	64"	184	165	153	139	265	242	215	191	458	421
	72"	212	191	178	163	305	279	248	221	522	481
16" o.c.	12"	64	57	51	45	93	85	75	65	132	122
	16"	79	70	63	56	114	104	92	80	162	150
	20"	94	84	76	68	138	126	111	97	192	178
	24"	110	99	90	81	164	150	132	116	222	206
	32"	128	115	105	95	192	176	155	137	262	243
	40"	148	133	122	111	222	204	180	160	302	279
	48"	170	153	141	128	255	234	207	185	342	315
	56"	194	175	162	148	292	268	237	213	392	359
	64"	220	199	185	169	332	305	269	242	442	405
	72"	248	225	210	193	375	344	305	275	502	461
24" o.c.	12"	98	88	80	72	142	129	114	100	248	229
	16"	118	104	95	85	172	157	138	121	298	275
	20"	142	124	113	102	210	191	167	147	358	331
	24"	168	147	135	122	252	229	201	178	422	390
	32"	195	172	158	144	298	270	237	211	502	461
	40"	225	199	184	168	338	307	269	240	582	535
	48"	258	228	211	193	382	347	305	272	662	611
	56"	292	258	239	219	430	391	342	305	752	695
	64"	328	290	268	245	482	438	385	342	842	779
	72"	365	323	298	272	538	490	432	385	942	871

83



Cold-formed Steel Roof Framing

There are provisions for Cold-formed Steel Roof Framing please refer to your code books and call your local building department before you begin if you wish to review these provisions.



R804

85

Minimum vent area

- 1/150 area vented space
- Exception: 1/300 one or more of the following conditions met:
 1. In Climate Zones 6, 7 and 8, a Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling.
 2. At least 40 percent and not more than 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the attic or rafter space.

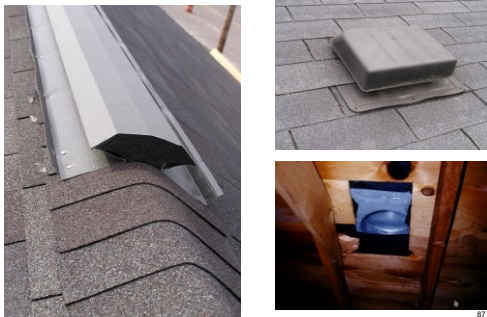
Ventilated attic area = 1000 sq. ft. $1/300 \times 1000 = 3.34$ sq. ft. $3.34 \times 144 = 480$ -sq. in. total net free vent area
Ridge vent $480 \times 50\% = 240$ -sq. in. free area Soffit vents →
120-sq. in. net free area

R806.2

88

R806 Roof Ventilation

Shall be not less than 1 to 150 of the space ventilated.
See exception.



87

Roof vents cut too deep.



88

Remember the Hidden Violations?



89



90

Unvented attic and unvented enclosed rafter assemblies

- Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) and unvented enclosed rafter assemblies (spaces between ceilings that are applied directly to the underside of roof framing members/rafters and the structural roof sheathing at the top of the roof framing members/rafters) shall be permitted if all the following conditions are met:
- All condition of section 1 – 5 have to be met**



R806.5

91

Unvented Attic Assemblies

- Prescribes requirements for unvented attic spaces, air-permeable and air impermeable insulation.
- Pre-approval BO



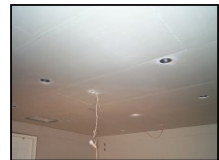
R806.4

92



R302.14 Insulation Clearance

- Combustible insulation shall be separated minimum 3 inches from recessed luminaires, fan motors and other heat producing devices.
- Recessed luminaires in building thermal envelope shall comply with N1102.4.3



94

R802.10 Wood Trusses



Truss design drawings - R802.10.1

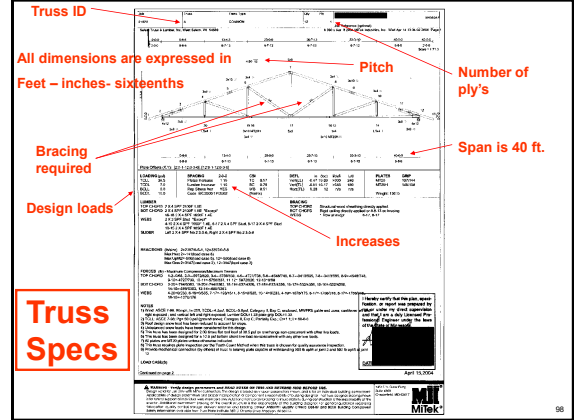
Truss design drawings, prepared in conformance to Section R802.10.1, **shall be provided to the building official and approved prior to installation.** Truss design drawings shall include, at a minimum, the information specified below. Truss design drawing shall be provided with the shipment of trusses delivered to the jobsite. . . Etc.



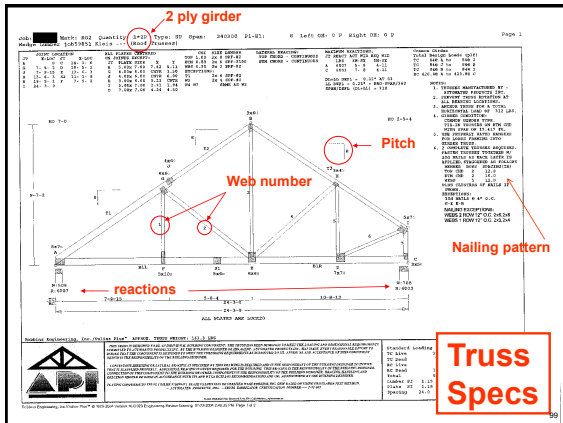
96

1. Slope or depth, span and spacing.
2. Location of all joints.
3. Required bearing widths.
4. Design loads as applicable.
 - 4.1. Top chord live load (as determined from Section R301.6).
 - 4.2. Top chord dead load.
 - 4.3. Bottom chord live load.
 - 4.4. Bottom chord dead load.
 - 4.5. Concentrated loads and their points of application.
 - 4.6. Controlling wind and earthquake loads.
5. Adjustments to lumber and joint connector design values for conditions of use.
6. Each reaction force and direction.
7. Joint connector type and description (e.g., size, thickness or gage) and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.
8. Lumber size, species and grade for each member.
9. Connection requirements for:
 - 9.1. Truss to girder-truss.
 - 9.2. Truss ply to ply.
 - 9.3. Field splices.
10. Calculated deflection ratio and/or maximum deflection for live and total load.
11. Maximum axial compression forces in the truss members to enable the building designer to design the size, connections and anchorage of the permanent continuous lateral bracing. Forces shall be shown on the truss design drawing or on supplemental documents.
12. Required permanent truss member bracing location.

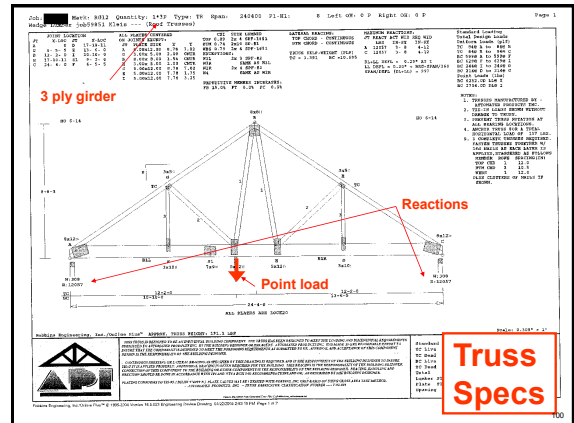
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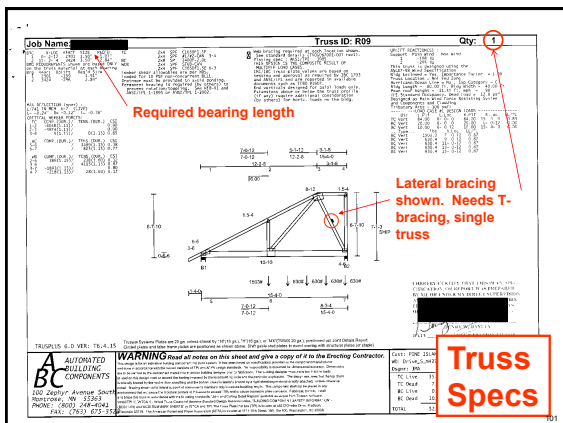
98



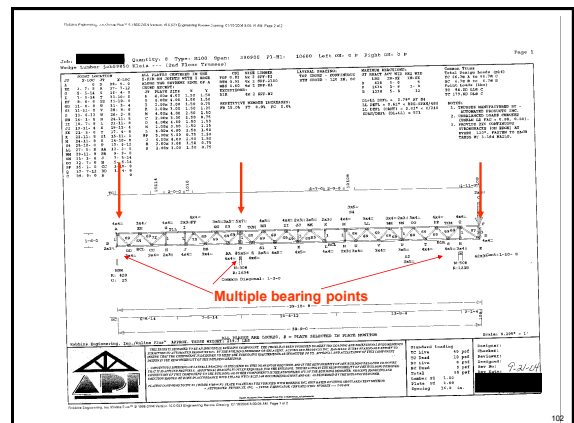
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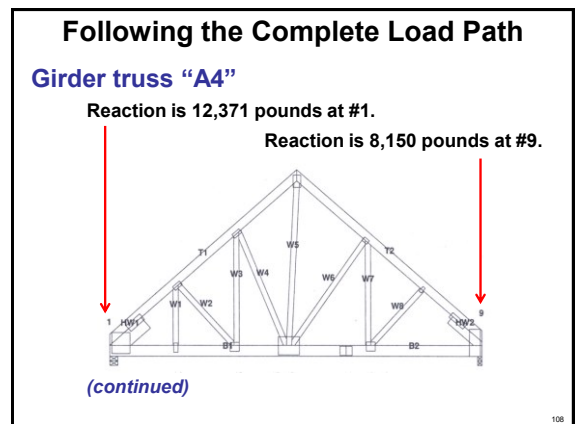
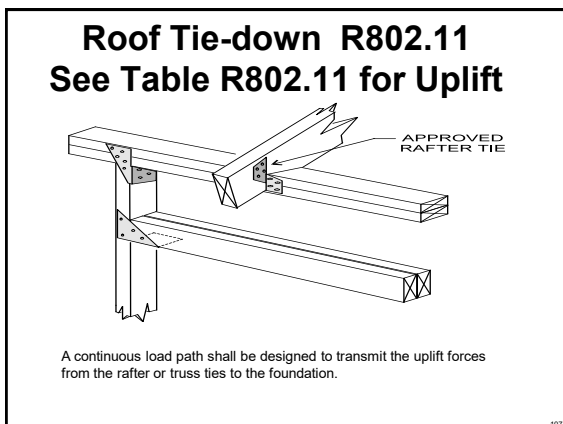
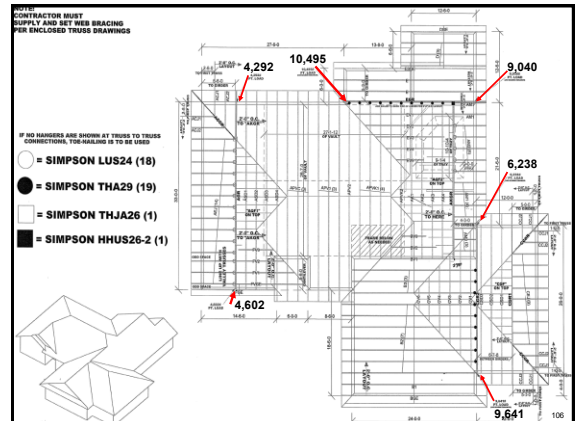
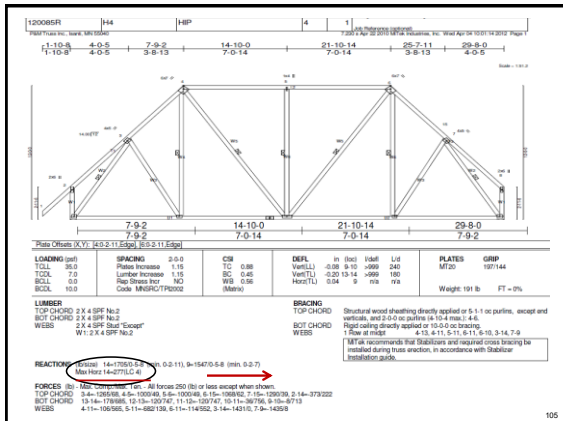
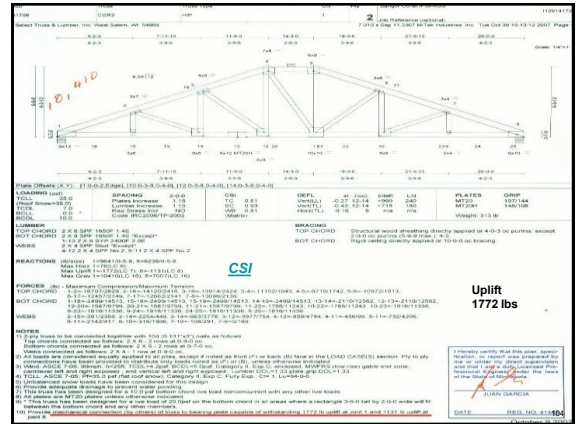
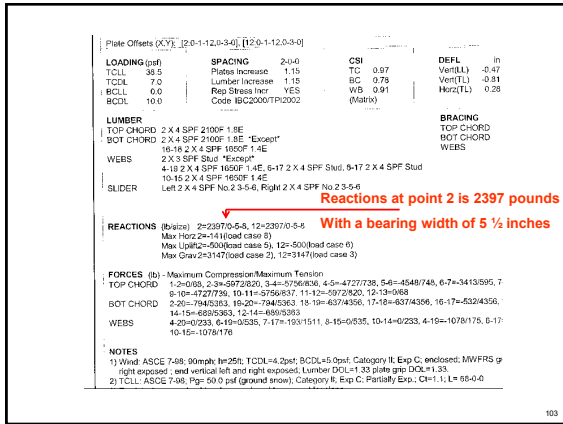
100



101



102



Following the Complete Load Path

Girder truss "A4"

What is the minimum **end bearing** required by the truss specifications?

REACTIONS (lb/size) 1=12063/0-5-4

According to the truss specs, at location number 1, **girder truss A4** requires **5 1/4 inches**, noted by the designation "1=12063/0-5-4." The "5" is in inches. The "4" is in sixteenths of an inch.



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Following the Complete Load Path

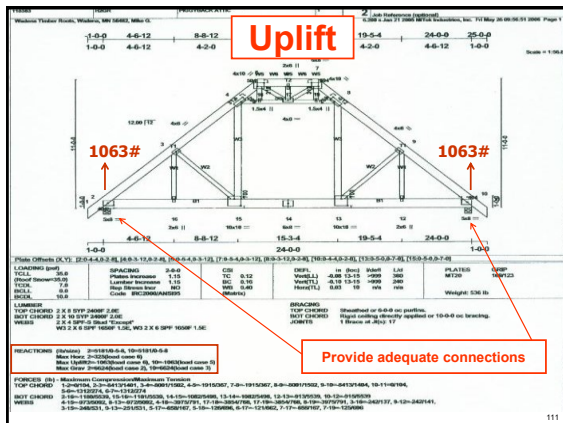
Girder truss D" - Bearing location #9

Truss notes (cont.)-

9) Provide **mechanical connection of truss to bearing plate** capable of withstanding **902 lb uplift** at joint 9...

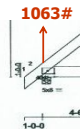


110



111

UPLIFT



If truss uplift is more than fastener and species of material provide, alternate methods (connectors) must be used!

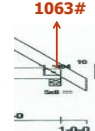


TABLE BB-1 Nominal Uplift and Lateral Capacity per Toe-Nail Joint Connection into Double Top Plate of Wall^{1,2,3,4,5}

Nail Type & Size	No. of Toe-Nails	Uplift Capacity (lbs) with Common Species ²						Lateral Resistance Capacity (lb) with Common Species ²					
		Load Duration Factor = 1.0						Load Duration Factor = 1.0					
		SP (15 = 1.50)	DF-L (15 = 1.50)	HF (15 = 1.50)	SP (15 = 1.50)	SPF(S) (15 = 1.50)	SPF(S) (15 = 1.50)	SP (15 = 1.50)	DF-L (15 = 1.50)	HF (15 = 1.50)	SPF (15 = 1.50)	SPF(S) (15 = 1.50)	SPF(S) (15 = 1.50)
16d (0.131x0.31)	3	174	138	96	90	60	264	243	210	204	180	180	
	4	232	184	128	120	80	352	324	280	272	240	240	
	5	290	230	160	150	100	440	405	340	330	300	300	
12d (0.100x0.25)	3	147	114	78	75	51	222	204	177	171	150	150	
	4	196	152	104	100	68	296	272	236	228	200	200	
	5	245	190	130	125	85	370	340	295	285	250	250	
10d (0.100x0.21)	3	125	96	66	66	45	222	204	177	171	150	150	
	4	168	132	92	88	60	296	272	236	228	200	200	
	5	210	165	115	110	75	370	340	295	285	250	250	

PERMISSION by WTCA T.BB-1

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113

Actual bearing length may vary per LVL manufacturer and load.

BEARING LENGTH REQUIREMENTS

REACTION (lbs.)	BEAM WIDTH		
	19 1/4"	31 1/2"	51 1/4"
2,000	1.75"	1.50"	1.50"
4,000	3.25"	1.75"	1.50"
6,000	4.75"	2.50"	1.75"
8,000	6.25"	3.25"	2.25"
10,000	7.75"	4.00"	2.75"
12,000	9.25"	4.75"	3.25"
14,000	10.75"	5.50"	3.75"
16,000	12.25"	6.25"	4.25"
18,000	13.75"	7.00"	4.75"
20,000	15.25"	7.75"	5.25"
22,000	16.75"	8.50"	5.75"
24,000	18.25"	9.25"	6.25"
26,000	19.75"	10.00"	6.75"
28,000	21.25"	10.75"	7.25"
30,000	22.75"	11.50"	7.75"

GENERAL NOTES

- Bearing length should never be less than 1 1/2" at ends, 3 1/2" at intermediate supports.
- Bearing across the full width of the beam is required.
- Bearing lengths are based on Microlam® LVL's bearing stress of 750 psi.



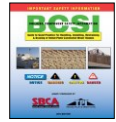
114



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Wood Trusses

R802.10.3 Bracing.



Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the construction documents for the building and on the individual truss design drawings. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practice such as the SBCA Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses.



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Labels

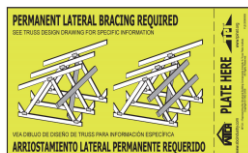


FIGURE B3-17

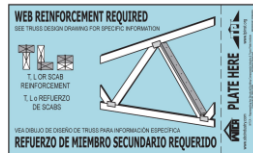


FIGURE B3-21

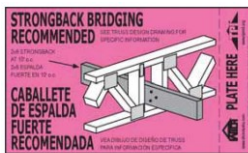


FIGURE B7-14

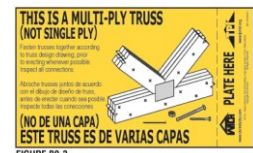
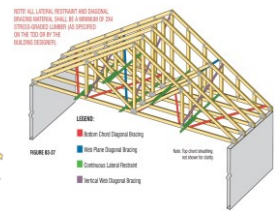
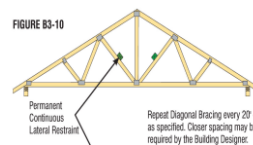


FIGURE B9-3

117

Bracing

Permanent web bracing is required to stabilize the truss members in the vertical plane of each truss for the life of the structure.



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Permanent Web Bracing

Three Types of Web Bracing:

- Continuous lateral bracing
- T-bracing
- Scab bracing

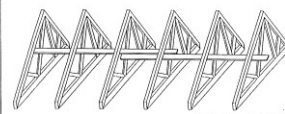
119

Web Bracing

- Lateral bracing required on 3 or more webs

Continuous Lateral Bracing

Some web members may require additional permanent bracing to fulfill truss design requirements. Please read all truss drawings for bracing requirements. In addition to providing individual drawings of trusses, web members requiring bracing will have the tag shown below attached at the points on the web that require a Permanent Lateral Brace. Please refer to individual drawings in the event that tags have been removed during truss erection.



Bracing must overlap at least 2 trusses where splices occur on truss. See above detail. Fasten bracing to truss per requirements shown on individual truss drawing.

In cases where at least 3 trusses do not have webs that line up refer to T-Brace Detail.

PERMANENT LATERAL BRACING REQUIRED
Truss design requires permanent bracing. Web bracing is required at the points on the web that require permanent bracing. See truss drawing for details.

120

Web Bracing

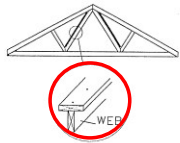
- T-Bracing is used on individual webs.

T-Brace Detail

A T-Brace can be used to replace Continuous Lateral Bracing in any area where webs are set up on at least 3 adjacent trusses. Brace must be fastened to NARROW edge of web using 12d common nails spaced not more than 6" on center. The T-Brace must cover at least 90% of web length. Bracing Size requirements are as follows:

On webs that are less than 14' in length - 2x4 Brace required.

On webs 14' or greater in length - 2x6 Brace required.



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Web Bracing

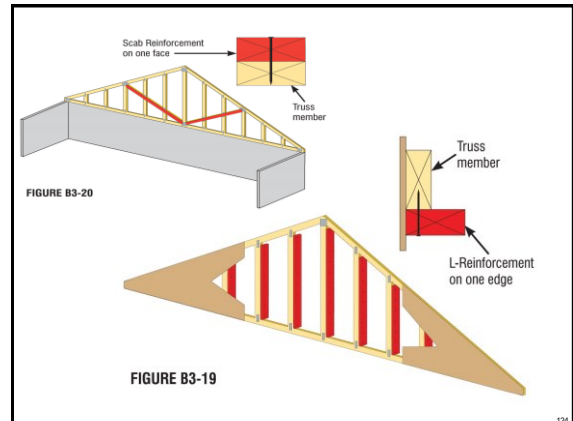
- 1 lateral brace on a 2x4 web can be substituted with 1 T-brace.
- 2 lateral braces on a 2x4 web can be substituted with a 2x6 T-brace or 2 scab braces applied to the side of the web.

122

Web Bracing

- T-braces are one piece of 2x material applied for 80 percent of the web length and attached with 16d nails 6 inches on center.
- Scab braces are applied on the face of the web with no more than one scab per face.
- Scab braces are 80 percent of the web length and applied with 16d nails or .128"x3" gun nails at 6 inches on center.

123



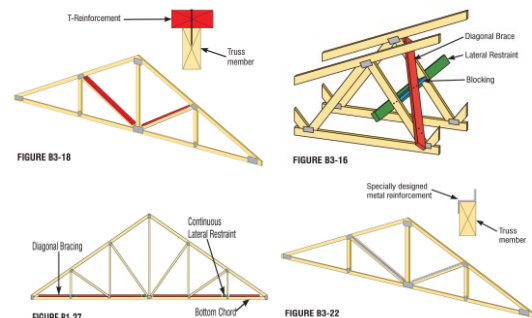
124

Web Bracing

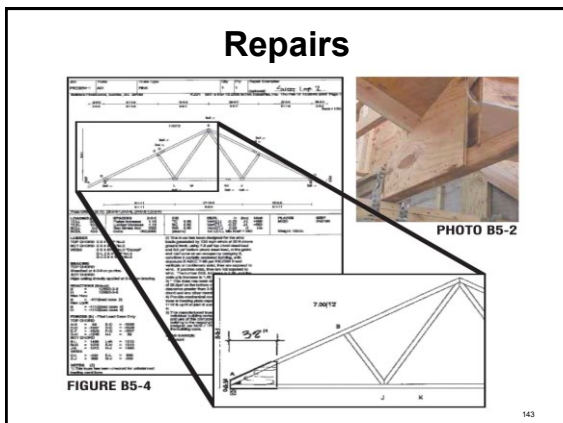
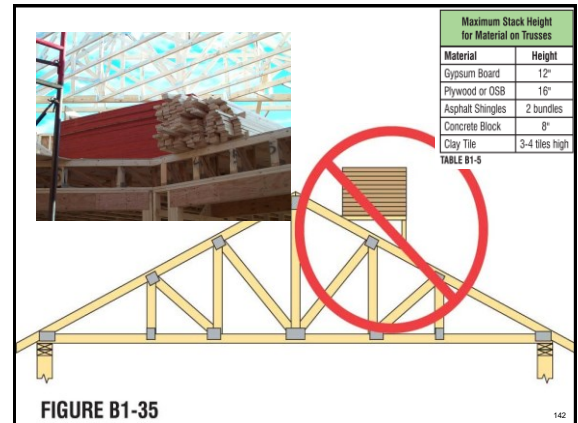
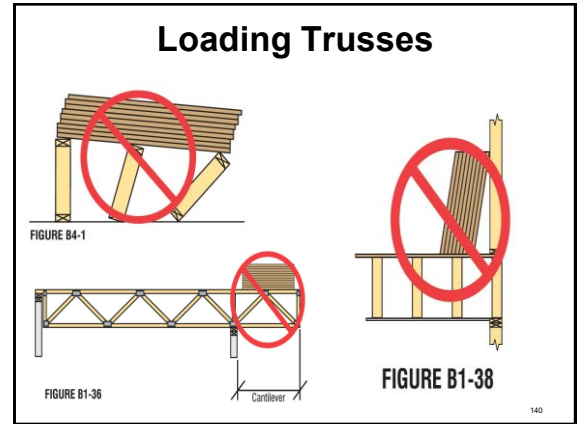
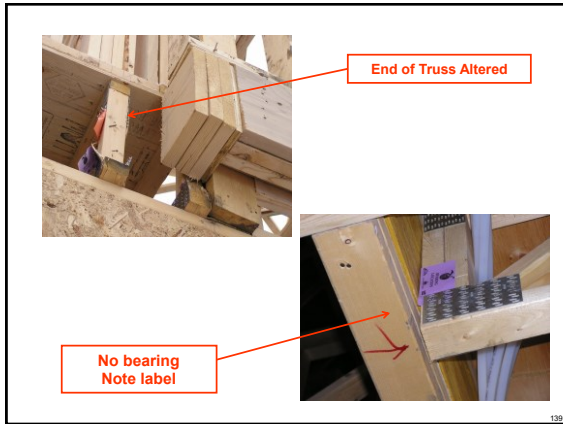
- T-bracing is used when a one of a kind truss is installed and neighboring webs or chords don't line up.
- The T-brace method requires no additional bracing. Continuous lateral bracing would require an additional diagonal brace.
- The lateral bracing may also be stabilized by connecting to another part of the roof structure, that is connected to another part such as the roof diaphragm.

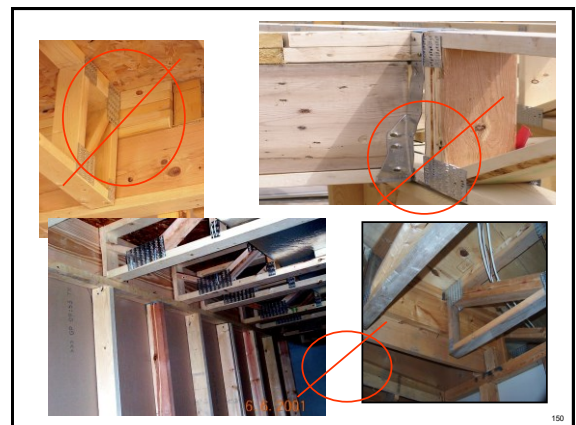
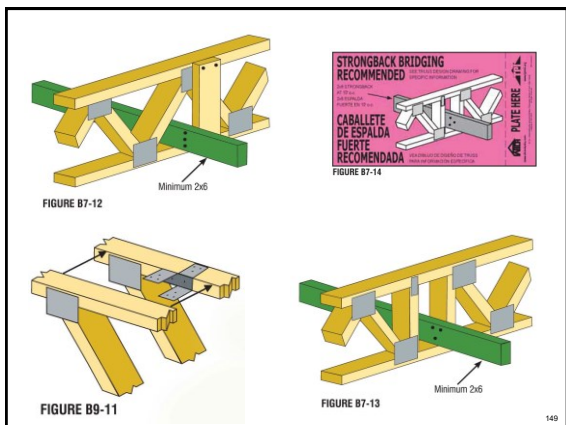
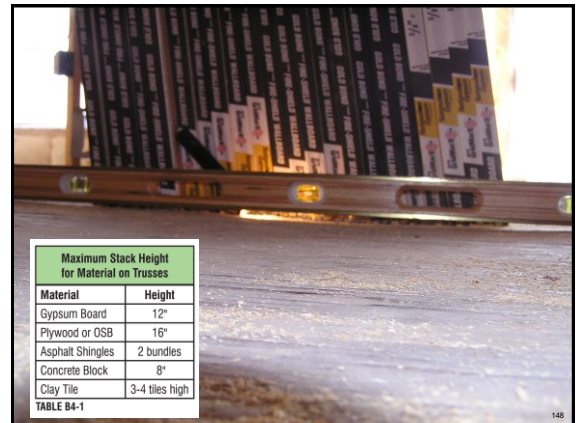
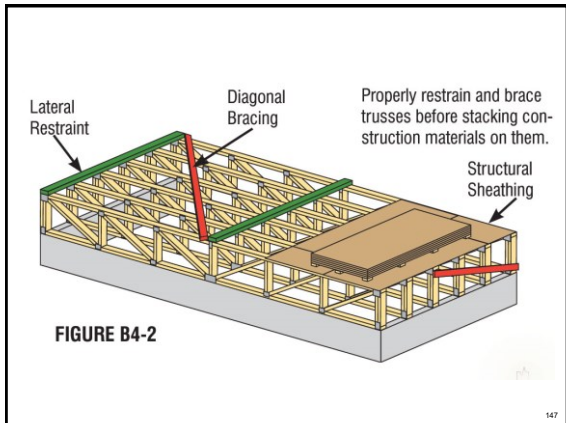
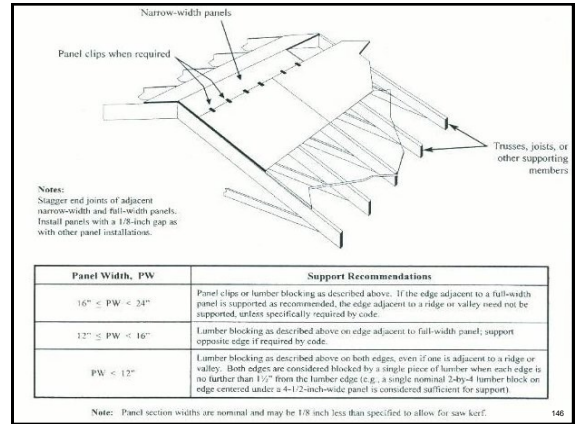
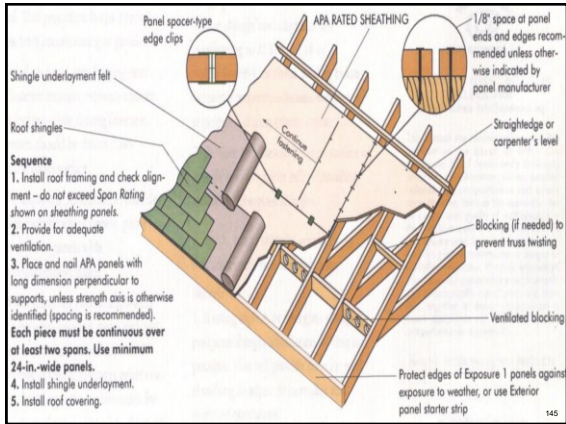
125

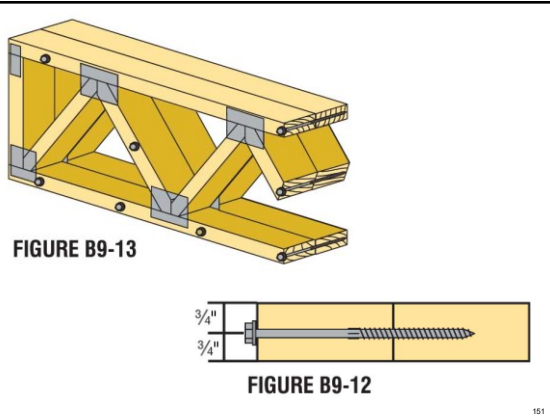
Bracing



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BCSI – Best Practices for Handling, Installing, Restraining & Bracing

For more info on:

- Truss repairs
- Girders
- Fall protection
- Jobsite storage
- Truss handling
- Toe-nailing for uplift
- Temporary bracing
- Construction loading



www.sbcindustry.com

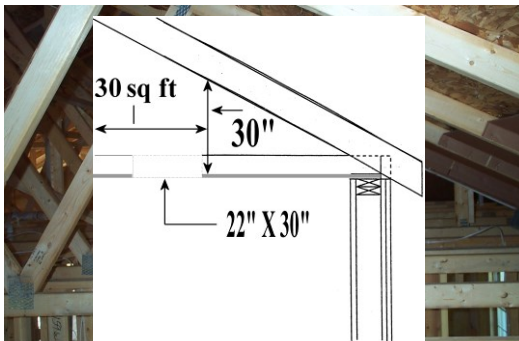
Roof Assemblies



R807.1 Attic Access

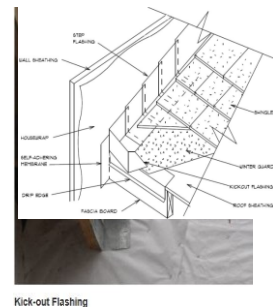
- The opening shall not be less than 22"x30" and shall be located in a hallway or other readily accessible location.
- When located in walls the opening shall be a minimum 22" wide by 30" high.
- When located in a ceiling the minimum unobstructed headroom in the attic space shall be 30" at some point above the access measured from the bottom of the ceiling framing members.

Attic Access



R903.2.1 Locations

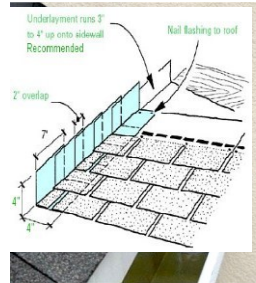
- Flashings shall be installed at wall and roof intersections
- Flashing shall be installed to divert the water away from eave of a sloped roof intersects a vertical sidewall.
- Flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than (No. 26 galvanized sheet).



Kick-out Flashing

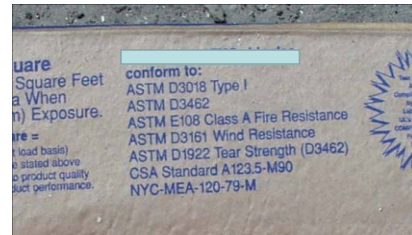
R905.2.8.3 Sidewall Flashing

- 4"x4" minimum dimension
- At the end of the vertical sidewall the step flashing shall be turned out in a manner that directs water away from the wall and onto the roof and/or gutter
- Each exterior cladding has different applications



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Asphalt Shingles



Asphalt shingles shall comply with ASTM D 225 or D 3462.

R905.2.4 Asphalt shingles.

158

Asphalt Shingles

- Asphalt shingles shall be tested in accordance with ASTM D 7158.
- Asphalt shingles shall meet the classification requirements of Table R905.2.4.1(1) for the appropriate maximum basic wind speed.
- Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D 7158 and the required classification in Table R905.2.4.1(1).



R905.2.4.1 Wind resistance of asphalt shingles

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Asphalt Shingles

TABLE R905.2.4.1 CLASSIFICATION OF ASPHALT ROOF SHINGLES

MAXIMUM ULTIMATE DESIGN WIND SPEED, V_{ult} FROM TABLE R301.2(2) (mph)	MAXIMUM BASIC WIND SPEED, V_{b50} FROM TABLE R301.2.1.3 (mph)	ASTM D7158* SHINGLE CLASSIFICATION	ASTM D3161 SHINGLE CLASSIFICATION
110	85	D, G or H	A, D or F
116	90	D, G or H	A, D or F
129	100	G or H	A, D or F
142	110	G or H	F
155	120	G or H	F
168	130	H	F
181	140	H	F
194	150	H	F

For 30: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

a. The standard calculations contained in ASTM D7158 assume Exposure Category B or C and a building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.

Table R905.2.4.1(1)

160

Asphalt Shingles



Exception: Asphalt shingles not included in the scope of ASTM D 7158 shall be tested and labeled to indicate compliance with ASTM D 3161 and the required classification in Table R905.2.4.1(2).

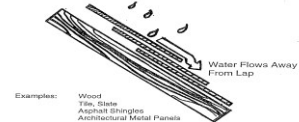
R905.2.4.1 Wind resistance of asphalt shingles

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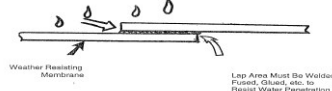
Weather Protection

Two Different Roofing Concepts:

Steep Roofs - Function by Shedding Water



Membrane Roofs - Function by Being Watertight



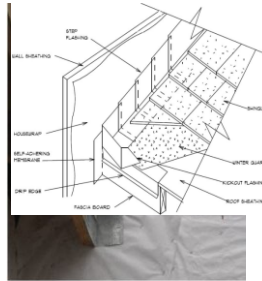
Examples:
Built-up Roofs constructed with Asphalt or Coal Tar Pitch
Single ply Roofs of Rubber or Plastic
Modified Bituminous
Structural Metal Panels
Spray in Place Polyurethane Foam

R903

162

Roof Assemblies

- Flashings shall be installed at wall and roof intersections
- Flashing shall be installed to divert the water away from eave of a sloped roof intersects a vertical sidewall.
- Flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than (No. 26 galvanized sheet).



Kick-out Flashing

R903.2.1 Locations

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Sidewall Flashing

Provisions should be made to divert water away from the house.



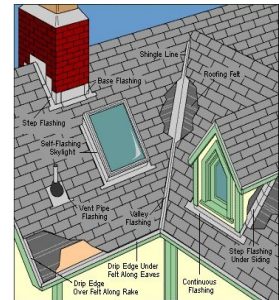
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Drip edge

- A drip edge shall be provided at eaves and gables of shingle roofs.
- Drip edge shall be overlapped a min. 2"
- Drip edges shall extend min. 1/4" below the roof sheathing **and** extend up the roof deck a min. 2"
- Drip edges shall be mechanically fastened to the roof deck at a max. 12" o.c. with fasteners as specified in Section R905.2.5.
- Underlayment shall be installed **over** the drip edge along eaves **and** under the underlayment on gables.
- Unless specified differently by the shingle manufacturer, shingles are permitted to be flush with the drip edge.

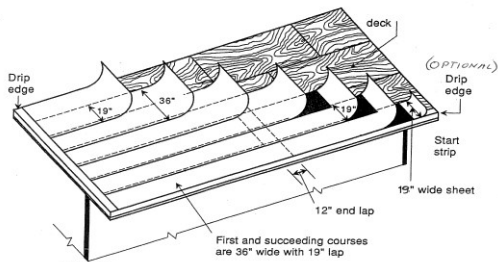


R905.2.8.5

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Underlayment Application

IN AREAS SUBJECT TO ICE BUILD-UP



ASPHALT SHINGLE APPLICATION
UNDERLAYMENT

R905.2.7

167



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R905.2.7 Distortions in the underlayment shall not interfere with the ability of the shingles to seal



Roof covering

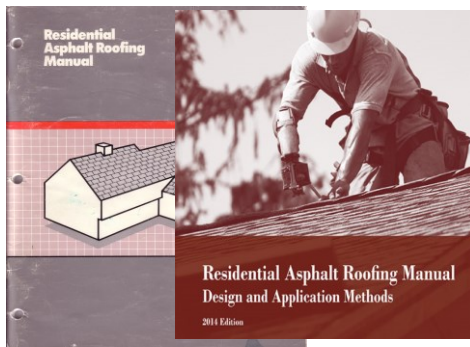
The ice protection requirement applies to the main structure, unheated attached garages, and heated detached accessory structures.



R905.2.7, R905.1.2

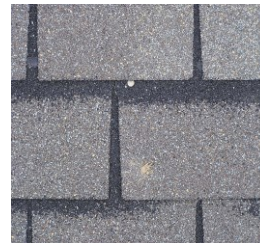
170

Asphalt Roofing Association



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R905.2.5 Fasteners

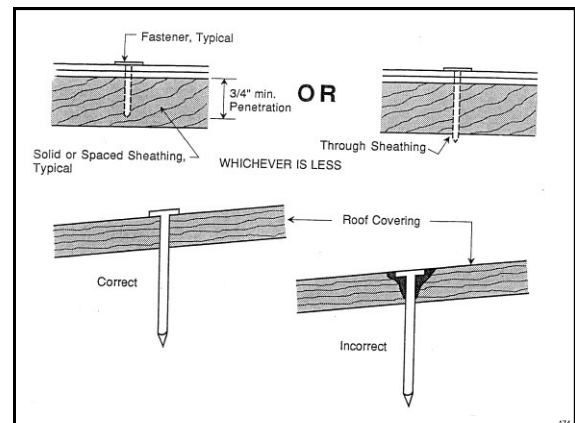


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R905.2 Asphalt shingles / R905.2.2 Slope.
 Roof slopes (2:12) or greater.
 Roof slopes (2:12) up to (4:12), double underlayment is required according to R905.2.7. 19" overlap



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Steep slope roofs require additional fasteners and an adhesive on each shingle tab.



R905.2.8 Flashing

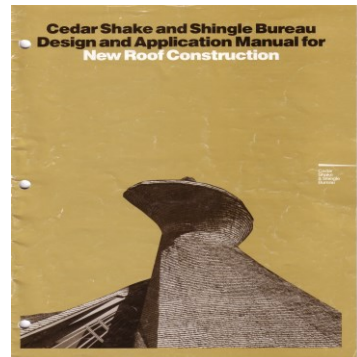
16, 20, 24



R905.8 Wood Shakes



Cedar Shake and Shingle Bureau



R905.8.6 Application

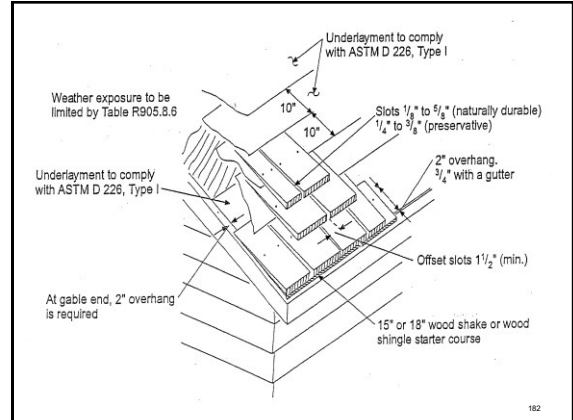
Side lap not less than 1 1/2" between joints in adjacent courses.



Keyway spacing between shakes shall be 1/8" to 5/8".



Weather exposure shall comply with Table R905.8.6.



Discussion Item # 4
Is this a code violation or just poor workmanship?



This Report identifies approved shake producing mills.

ES LEGACY REPORT

ER-5133

Reissued November 1, 2004

ICC Evaluation Service, Inc.
www.icc-es.org

Business/Regional Office • 5300 Workman Mill Road, Whittier, California 90601 • (562) 699-5943
Regional Office • 400 Montclair Road, Suite A, Birmingham, Alabama 35215 • (205) 566-8800
Regional Office • 4051 West Plasmor Road, Country Club Hills, Illinois 60478 • (708) 799-2305

Legacy report on the 1997 Uniform Building Code™

DIVISION: 07—THERMAL AND MOISTURE PROTECTION
Section: 07310—Shingles

WESTERN RED CEDAR ROOF-COVERING SYSTEMS

CEDAR SHAKE AND SHINGLE BUREAU
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CANADA

WALDUN FOREST PRODUCTS PARTNERSHIP
9393-287TH STREET
MAPLE RIDGE, BRITISH COLUMBIA V2W 1L1
CANADA

R905.8.9 Label Required



Watch where you walk when on a roof!



R905.4 Metal Roof Shingles



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Table R905.10.3 Metal Roof Coverings Standards and Installation

TABLE R905.10.3(1)
METAL ROOF COVERINGS STANDARDS

ROOF COVERING TYPE	STANDARD APPLICATION RATE/THICKNESS
Galvanized Steel	ASTM A 653 G90 Zinc Coated
Stainless Steel	ASTM A 240, 300 Series Alloys
Steel	ASTM A 924
Lead-coated Copper	ASTM B 101
Cold Rolled Copper	ASTM B 370 minimum 16 oz/square ft and 12 oz/square ft high yield copper for metal-sheet roof-covering systems; 12 oz/square ft for preformed metal shingle systems.
Hard Lead	2 lb/ sq ft
Soft Lead	3 lb/ sq ft
Aluminum	ASTM B 209, 0.024 minimum thickness for rollformed panels and 0.019 inch minimum thickness for preformed shingles.
Terne (tin) and terne-coated stainless	Terne coating of 40 lb per double base box, field painted where applicable in accordance with manufacturer's installation instructions.
Zinc	0.027 inch minimum thickness; 99.995% electrolytic high grade zinc with alloy additives of copper (0.08% - 0.20%), titanium (0.07% - 0.12%) and aluminum (0.015%)

For SI: 1 ounce per square foot = 0.305 kg/m²; 1 pound per square foot = 4.214 kg/m²; 1 inch = 25.4 mm; 1 pound = 0.454 kg.

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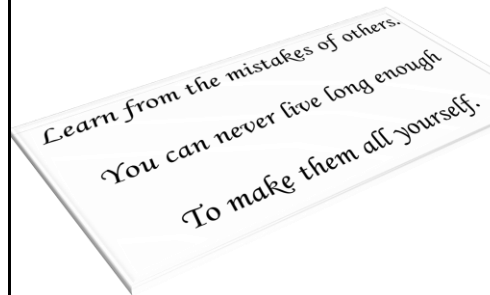
Summary

- Verify all code requirements.
- Call your local building department with questions.
- ...And remember: "Life is good." (Brent Snyder 2006)



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Short Cut



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